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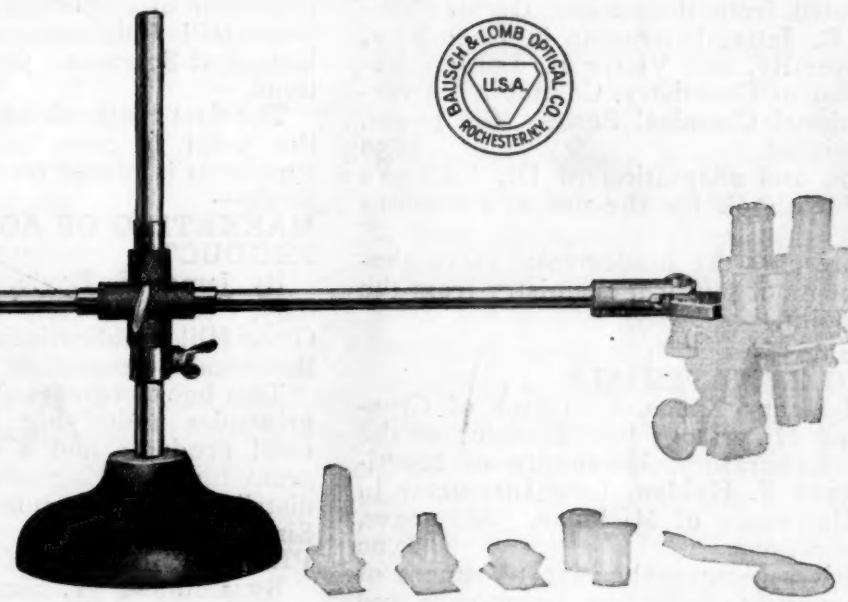

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DIELECTRIC CONSTANT AND MOLECULAR STRUCTURE[1]

As I recall the scholarly and witty addresses delivered by my predecessors of the past *n* years, I am forced at the outset to confess to an inferiority complex of *n* dimensions. Three years ago Stewart initiated us into the mysteries of acoustical filters and made me wonder if it might not be possible to devise filters to exclude from our hearing those sounds made at night by the street cars and fire departments of Kansas City. Two years ago Saunders, though with characteristic modesty, made us all feel the importance and charm of spectroscopy. Last year Swann spoke on electrodynamics—I do not recall just what he said, but I remember the rapture with which I listened to this his "swan" song. I can not compete in wit or scholarship with these precedents, but I do claim a unique position in that I have the temerity to speak on a subject to whose development I have made no contribution, though I have encouraged some others to investigate it. In daring to speak on this subject, I fear that I place myself in a class with that officer, early in the war, who was commissioned to organize a committee to investigate one of the most highly technical and mathematical problems of the war and who carefully picked a committee of non-scientific men in order that its findings might not be prejudiced in favor of scientific methods of investigation.

My subject is "Dielectric Constant and Molecular Structure." Only twenty-five years ago the atomic structure of matter was held by some eminent scientists to be only a convenient hypothesis, accounting well for observed phenomena of chemistry and physics, but unsupported by direct unequivocal proof. In my college text-book of chemistry are the words: "It (the atomic theory) is not a statement of anything found by investigation. It is not an established fact. It may or may not be literally true, but . . . it furnishes a very convenient means of interpreting the facts of chemistry." Since that time atoms and molecules have been counted, individually weighed, dissected and their parts studied in many aspects. The question in these days is not, "Do molecules exist?" It is rather, "What is their structure and what forces hold their parts together and account for their properties?" In answer to this question we say

[1] Address of the vice-president and chairman of Section B, American Association for the Advancement of Science, Kansas City, December 30, 1925.

unhesitatingly that every molecule consists of a certain number of atoms, each of which is composed of a known number of protons and electrons. We are less ready to specify the arrangement of the atoms within the molecules and are still less prepared to describe those forces which account for chemical union and physical properties, except in the most general way.

Assuming that the facts of chemistry tell us what atoms make up a molecule, let us review some methods of investigating further its structure. These methods are principally five in number.

(1) The ratio of the gaseous specific heat at constant pressure to that at constant volume is, on classical theory $(n+2)/n$, where n is the number of degrees of freedom which share in the thermal energy of the molecules. From this we are able to draw some conclusions regarding the structure of the simplest molecules, but this method is complicated by the fact that the energy is distributed according to quantum laws which approximate to the classical laws only in limiting cases, so that this method is of relatively little use.

(2) The arrangement of atoms in crystals, as found by X-ray diffraction methods, gives a clue to the geometrical arrangement of atoms in molecules, since it is reasonable to assume that the particular atomic force fields which account for the arrangement of atoms in crystals are responsible also for their arrangement in molecules.

(3) The molecular band spectra, as interpreted by the quantum theory, relate the frequency difference $\Delta\nu$ in the fine structure of a band to the moment of inertia I of the molecules by the relation $\Delta\nu = h/(4\pi^2 I)$. From the knowledge of I thus gained, the distances between the atomic nuclei in a number of biatomic and triatomic molecules have been determined. Furthermore, the frequency differences between band heads, and also the small variations of $\Delta\nu$ within a band, give some information regarding the degree of "firmness" with which these nuclei are held together.

(4) Phenomena such as molecular association, dissociation, ionization and adsorption indicate strong force fields around certain types of molecules, which presumably result from unsymmetrical arrangements of their electrical constituents. Typical molecules of this so-called "polar" class are H_2O, NH_3, HCl, SO_2, CH_3OH, while non-polar molecules are H_2, O_2, C_6H_6, CO_2.

(5) Particularly significant are phenomena occurring when molecules, by being placed in an electric field, are distorted or oriented. Under this heading we include refractivity and dielectric properties. In this address I wish to review the interpretation of specific inductive capacity, or dielectric constant, and call attention to the ways in which its study contributes to our knowledge of molecular structure.

Like many other things electrical, the clue to the interpretation of dielectric phenomena was given by Faraday, who pointed out that matter in an electric field should become electrically polarized by induction and thereby give rise to a field which would partially neutralize the applied field. Lorentz interpreted this induction in terms of modern ideas of molecular structure. Debye and J. J. Thomson pointed out a second factor contributing to dielectric action. Gans and Pauli have elaborated and refined the theory, and recent tests seem to have established its sound basis.

THEORY OF DIELECTRICS

Consider an electron which forms part of the structure of a molecule. If this molecule is placed in an electric field E the electron is displaced a distance s from its equilibrium position (or orbit. We shall speak of electron positions with the understanding that these are the time average positions). Whatever be the law of force which opposes this displacement, the shift may be taken as proportional to the displacing force for *small* displacements, and we may put $F = Ee = s/\gamma$ where γ is a binding constant related to the natural period of vibration of the electron T about its equilibrium position by the expression $T = 2\pi\sqrt{m\gamma}$. The displacement s is equivalent to the creation of an electric doublet of moment $\mu = es = Ee^2\gamma$. If there are N such displaceable electrons per unit volume, then the electric moment per unit volume is $P = NEe^2\gamma$, which is called the *polarization*. Since $P = (\varepsilon - 1)E/4\pi$, we have at once for the dielectric constant ε the expression

$$\varepsilon - 1 = 4\pi Ne^2\gamma. \qquad (1)$$

This equation must be modified in view of several additional considerations.

(1) Not all electrons are similarly situated in the molecule. Suppose each molecule to contain ν_p electrons of type p, characterized by a binding constant γ_p and suppose that there are n types of electrons per molecule and N molecules per unit volume. We then have

$$\varepsilon - 1 = 4\pi Ne^2 \sum_1^n \nu_p \gamma_p. \qquad (2)$$

(2) We have neglected the effect produced by the field of its neighbors on the electron displacement in each molecule. If intermolecular distances are large compared with molecular dimensions (as in gases), consideration of this interaction leads to

$$\frac{\varepsilon - 1}{\varepsilon - 1 + \alpha} = \frac{4\pi Ne^2}{\alpha} \sum_1^n \nu_p \gamma_p, \qquad (3)$$

where $\alpha = 3$ for the random molecular arrangement

in gases and liquids, but may have other values in solids. (3) We have neglected to consider the effect produced on the displacement of any electron by that of the other electrons in the same molecule. This is done by introducing a factor L_p, which is greater than unity, but probably not much greater so that it is generally neglected. The more general expression is therefore

$$\frac{\varepsilon-1}{\varepsilon-1+\alpha}=\frac{4\pi Ne^2}{\alpha}\sum_1^n \nu_p\,\gamma_p\,L_p \qquad (4)$$

This is, essentially, the theory of Lorentz. Since N equals the density D divided by the molecular mass M, and since $\alpha=3$ for liquids and gases, this expression may be written

$$\frac{\varepsilon-1}{\varepsilon+2}=AD, \qquad (5)$$

where A is a constant for any given substance. This is the well-known Clausius-Mossotti relation, which is very accurately true for some substances but which fails to account for variations with temperature observed with the so-called "polar" compounds.

If each molecule is a permanent electric doublet of moment μ, *i.e.*, if the center of charge of its constituent electrons does not coincide in position with that of its positive parts, then there is a tendency for molecules to orient themselves with their electric axes pointing in the direction of the applied field. This orientation is hindered by the kinetic reactions of thermal agitation, so that a certain statistical average degree of alignment results, which depends on the moment of the doublet, the strength of the field and the temperature. Boltzmann's theorem enables us to express the number of molecules oriented between angular limits ϑ and $\vartheta+d\vartheta$ with the field as

$$dN=CN\varepsilon^{\frac{\mu E\cos\vartheta}{kT}}\sin\vartheta\,d\vartheta$$

where C is a constant which is very readily evaluated, and k is the Boltzmann gas constant. Each of these molecules contributes an amount $\mu\cos\vartheta$ to the polarization P. By integration over all angles the total polarization from this cause is found to be

$$N\mu(\mu E/3kT+\mu^3E^3/45k^3T^3+\ldots)$$

in which the terms beyond the first are generally negligible. Including this polarization due to orientation of molecules with that due to the shift of electrons, we have the equation of Debye

$$\frac{\varepsilon-1}{\varepsilon+2}=4\pi N\left(\frac{e^2}{3}\sum_1^n \nu_p\,\gamma_p\,L_p+\frac{\mu^2}{9\,kT}\right)=\left(A+\frac{B}{T}\right)D. \qquad (6)$$

Application to gases: In the case of gases this equation has only recently been tested with high accuracy, since the value of ε is so near unity that it must be determined with very high precision to give a significant value of $\varepsilon-1$. For instance an error of 0.001 per cent. in measuring ε leads to an error of 2 per cent. in $\varepsilon-1$ for nitrogen gas. Several satisfactory methods have recently been devised to take advantage of modern technique of high frequency circuits. One of these methods, first applied by Herweg and later improved by Zahn, consists in amplifying the electrical beats between two differently tuned oscillating circuits, one of which contains the experimental condenser which is alternately filled and emptied of gas. The electrical beats are made audible by a telephone receiver and produce acoustical beats with the sound from an electrically driven tuning fork. By always adjusting to zero beats and taking extraordinary precautions for shielding and steadiness, this method is capable of measuring a change in capacity of one part in two million.

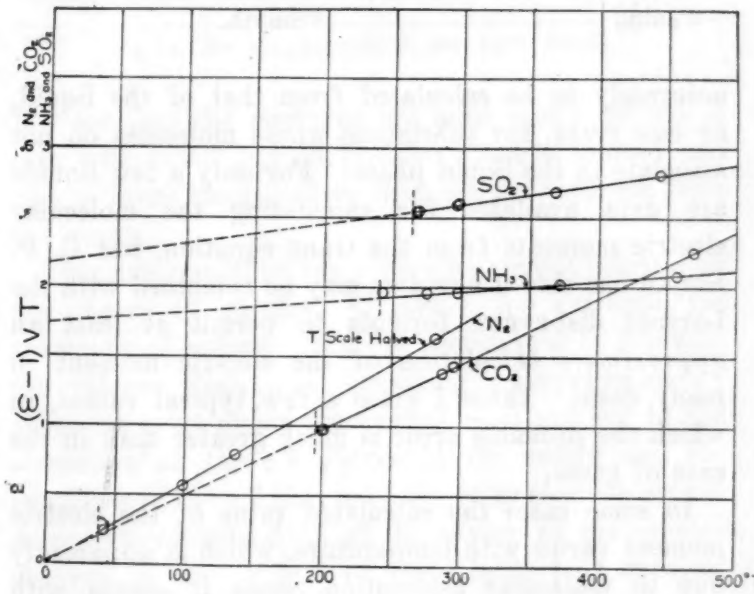


Figure 1 shows the variation of $\varepsilon-1$ with T. v is the reciprocal of the density, whence the result of plotting $(\varepsilon-1)\,v\,T$ against T should be a straight line if equation (6) is correct. (The factor $\varepsilon+2$ in these cases is constant within the limits of accuracy of plotting.) The slope of each straight line gives the quantity A, from which the "binding" constant γ may be computed, while the intercept gives the quantity B or the permanent electric moment μ of the molecule. Some of these moments are given in Table I.

Application to liquids: Debye's equation (6) does not describe very accurately the dielectric constant of liquids. Gans has shown that this is due chiefly to mutual actions between molecules which are not sufficiently allowed for in the approximate treatment of this effect used for gases, and has derived a much more complicated equation which reduces to equation (6) for fluids of low density like gases. This equation is apparently accurate for both liquids and gases (though a part of the mathematical analysis has been questioned) since it meets the most severe possible test: it permits the dielectric constant of the vapor

TABLE I

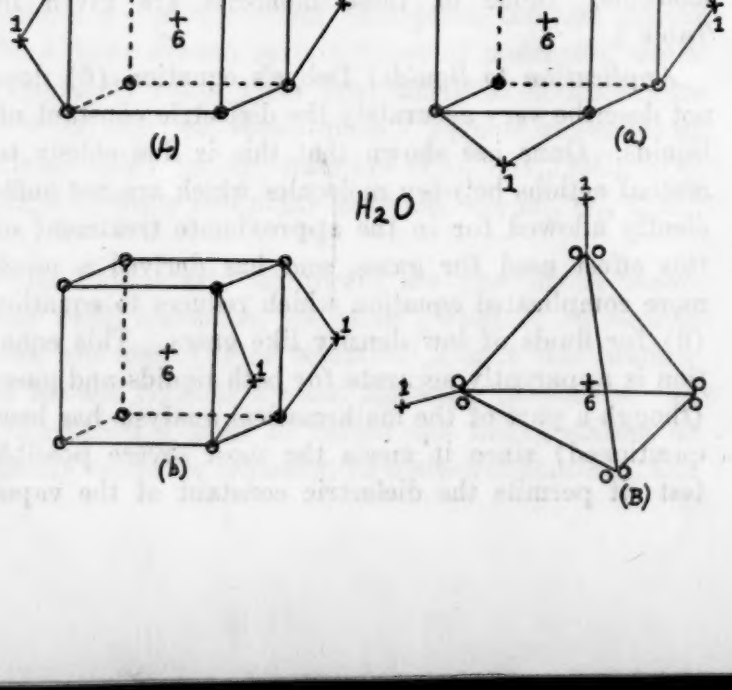
ELECTRIC MOMENTS μ OF MOLECULES

Gas[2]	μ	Liquid[3]	μ
HCl	1.03(10)$^{-18}$	H_2O	1.98(10)$^{-18}$
HBr	0.79	CH_3OH	1.78
HI	0.38	C_2H_5OH	1.85
NH_3	1.44	C_3H_7OH	1.98
SO_2	1.61	C_4H_9OH	2.06
H_2O	1.87	$C_5H_{11}OH$	2.15
C_2H_2	0.00	C_6H_6	0.20(?)
C_2H_4	0.00	$C_6H_5CH_3$	0.40
C_2H_6	0.00	$C_6H_5C_2H_5$	0.46
α C_4H_8	0.37	$(CH_3)_2O$	1.37
N_2	0.00	$C_2H_5)_2O$	1.37
CO_2	0.06	$(CH_3)_2S$	1.27

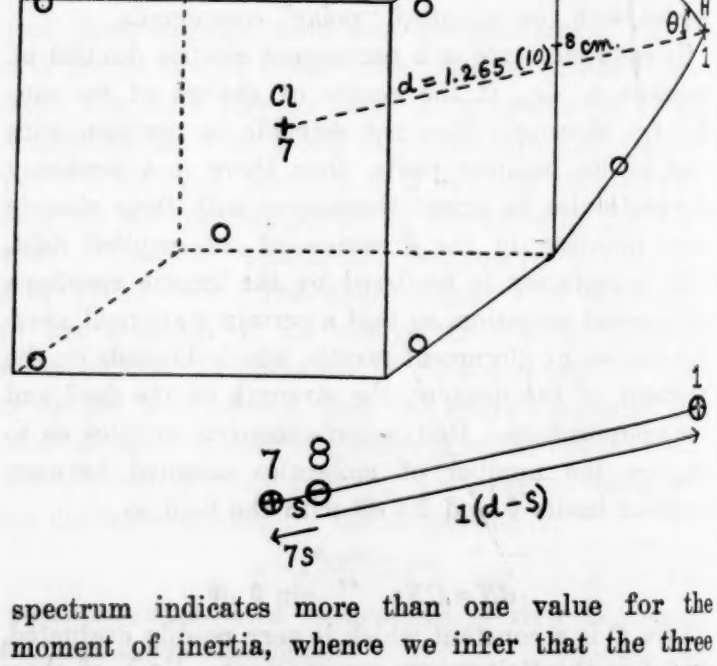
[2] Zahn. [3] Smyth.

accurately to be calculated from that of the liquid, or *vice versa,* for substances whose molecules do not associate in the liquid phase. For only a few liquids are data available for calculating the molecular electric moments from the Gans equation, but C. P. Smyth has shown how this may be combined with the Lorentz dispersion formula to permit at least an *approximate* calculation of the electric moment in many cases. Table I gives a few typical values, in which the probable error is much greater than in the case of gases.

In some cases the calculated value of the electric moment varies with temperature, which is apparently due to molecular association, since it occurs with those substances for which there is independent evidence of association. In fact Kalish has adapted Smyth's equations to estimate the degree of association in liquids at various temperatures. There is some indication that, in such cases, association disappears at the boiling point, but the evidence is inadequate to permit definite statement at present.



Some applications to molecular structure: Consider the familiar chemists' scheme for indicating the structure of a water molecule H-O-H. Or consider the more elaborate electronic configuration of the Lewis-Langmuir theory (L, Fig. 2). These arrangements are symmetrical in such a way that the center of charge of the electrons and that of the positive nuclei coincide at the center of mass of the molecule. Such molecules would have zero electric moment; yet the variation of dielectric constant with temperature shows that the water molecule is one of the strongest of molecular doublets. Therefore, among the possible arrangements and motions of the electrons and nuclei in a water molecule, we may exclude all symmetrical models and consider only those models which can give the proper electric moments. Furthermore, the band



spectrum indicates more than one value for the moment of inertia, whence we infer that the three atomic nuclei are not situated on the same straight line. Models (a), (b) or (B) would satisfy the requirements of both dielectric constant and band spectrum as far as we can tell. Thus the consideration of dielectric constants may be used to *test* molecular models, but will not explicitly *give* us the models.

Consider further the hydrogen chloride molecule HCl. To illustrate the argument, take the Lewis-Langmuir model (Fig. 3), although the argument is general for any model. The chlorine nucleus and inner electrons give a net charge of +7 within an outer group of eight electrons whose mean positions may, to a first approximation, be the corners of an octet, while the hydrogen nucleus is symmetrically bound to electrons at two adjacent corners of the cube. The distance d between the Cl and H nuclei is known to be 1.265(10)$^{-8}$ cm, from the moment of inertia as

given by the band spectrum. If the eight electrons were symmetrically situated about the Cl nucleus, the resultant charge of the entire cube would be equivalent to that of one electron at the center. This, together with the H nucleus, would constitute an electric doublet of moment $\mu = ed = 6.039(10)^{-18}$ c. g. s. But the presence of the H nucleus distorts the cube by attracting the electrons to new positions of equilibrium, indicated by the circles. Thus the center of charge of the electron system is shifted by an amount s toward the H nucleus. The system of charges is therefore equivalent to $+7$, -8 and $+1$ situated as indicated below in the figure. The resultant electric moment, as indicated by arrows, is $\mu = e(d - 8s)$. Since d is known from band spectrum data and μ from dielectric constant data, we may calculate the average shift s to be $0.13(10)^{-8}$ cm, which is a reasonable value.

Now there is an entirely independent method of calculating this shift s of the electron configuration, also based on the theory of dielectrics. The constant γ in equation (6) is the electronic shift per unit distorting force and may be evaluated from the constant A if we make the close approximation of considering the entire polarization of the molecule as due to the outer eight valence electrons. For HCl we thus find that $\gamma = 1.41(10)^{-6}$ cm/dyne. Now if we knew the exact configuration and dimensions of the electron structure we could consider each electron individually, compute its shift x due to the attraction of the H nucleus and average for all eight electrons the component of this shift in the direction of the molecular axis—thus finding s. Not knowing the configuration accurately enough for this, we may make a first approximation by supposing that this average shift will be the same as if all electrons were initially located at their unshifted average position at the cube center Cl, and then calculate the shift by the equation $e^2/(d-s)^2 = s/\gamma$. Thus we find $s = 0.26(10)^{-8}$ cm. These two methods of calculating s agree as to order of magnitude, but the second method gives a larger value. The approximations regarding location of the electrons and linear relation between force and shift over the entire shift x may account for such discrepancy as exists.

Other examples of applications of the theory might be cited, but I shall heed the Golden Rule and hasten on. The first term in the Debye equation, the term involving the binding constant A, is identical with the first term of the Lorentz optical dispersion formula. Thus the binding constant γ may be calculated from refractivity data, which are much more extensive than are dielectric constant data, and are available for ions in solution as well as for neutral molecules. Born and Heisenberg, Fajans and Jooz, Smyth and others have thus calculated the "binding constant" (or its equivalent, the "deformability") of various electron configurations. Some of these are shown in Table II.

TABLE II

SYSTEMS OF EIGHT DISPLACEABLE ELECTRONS

	0^{--}	F^-	Ne	Na^+	Mg^{++}	A^{+++}	Si^{++++}
Ion core	+6	+7	+8	+9	+10	+11	+12
$\gamma(10)^6$	1.52	0.54	0.22	0.108	0.062	0.037	0.022

Atom	He	Ne	A	Kr	Xe
$\gamma(10)^6$	0.43	0.22	0.91	1.37	2.25

Molecule	HF	HCl	HBr	HI
$\gamma(10)^6$	0.41	1.41	1.96	2.91

γ is the displacement per unit force.

We see that the electrons are most easily shifted in ions with small central positive charges (cores) and also in large atoms, where they are far removed from the center.

This deformability has a very important bearing on the theory of spectra. Consider, for example, the spectrum of sodium. We are accustomed to think of the valence electron as executing an approximately elliptical orbit about the central core, subject to the attraction of the +9 charge at the center and the repulsion of the -8 charge of the outer electron group. A general consideration of the motion of the valence electron in such a field of force leads to a spectral series formula of the Ritz type

$$\nu = R\left(\frac{1}{(n^1 + k^1 + \ldots)^2} - \frac{1}{(n + k + \ldots)^2}\right)$$

in which the terms k arise from the repulsive noncentral character of the field due to the outer electron shell. While formally acceptable, this picture is physically untenable since it leads to the wrong algebraic sign for the terms k. Stated physically, the departure from a central force field must be in the direction of an *attraction* rather than a *repulsion* on the valence electron.

Born and Heisenberg and Jones and Boyce have pointed out that such an attraction should result from the distortion of the electron shell in the field of the valence electron. This distortion, when the valence electron is distant r, amounts to a shift $s = \gamma e^2/r^2$ making the atom core a doublet of moment $\mu = 8se$ which attracts the valence electron with a force $2\mu e/r^3$ or $16\gamma e^4/r^5$. When this force, thus computed with the aid of γ given by refractivity or dielectric constant data, is included in deriving the Ritz series formula, the theoretical values of k are found to agree rather acceptably with the actual values for sodium

and about a dozen other elements whose spectra are of similar type.

In concluding let me remind you that many other aspects of dielectric constant deserve more study. There are the phenomena of electric double refraction and of the variation of dielectric constant with field strength which should open the way to a study of the law of force by which the electrical constituents of molecules are held together. There is the study of refractivity of particular electron groups and of chemical radicals, which can shed much light on the atomic arrangements in complicated molecules. There is the interesting question of the conditions of pressure and temperature at which the classical theory of dielectrics fails and a quantum theory must be employed—and of the nature of this quantum theory. There are innumerable problems of the effects of the strong local force fields of dipole molecules on such properties as heat of sublimation, association, dissociation, ionization, adsorption, conductivity, osmotic pressure, residual valency, electrical double layers, and so on. While all these have been pretty definitely related to deformability of molecules or to their electric doublet character, the field is an open one for research which will render more precise our understanding of this group of phenomena.

K. T. COMPTON

PRINCETON UNIVERSITY

ANOTHER OUTLOOK ON THE CHEMICAL REGULATION OF RESPIRATION[1]

THE regulation of respiration is a subject which is engaging the attention of physiologists, but the fluctuations of respiration in numerous pathological conditions have a significance which must likewise hold the interest of clinicians. I have, therefore, attempted to review a theory which seems at present to offer the most complete explanation of respiratory phenomena.

When respiration is suspended three outstanding changes in the arterial blood occur: an increase in the carbon dioxide tension; an increase in the hydrogen ion concentration and a decrease in the oxygen tension. When respiration is resumed the blood returns to its normal condition, and the conscious desire to breathe disappears. Such observations suggest that any one of these changes may be the factor controlling respiration, and several theories have been proposed explaining the chemical mechanism of respiratory control. According to one theory the respiratory center is stimulated by the free hydrogen ions of the arterial blood; according to another theory by a specific action of carbon dioxide, and according to another by a lack of oxygen in the arterial blood.

Several years ago my studies on the volume-flow of blood led me to doubt the prevailing theories of respiratory control, for I found that respiration could be stopped by simply accelerating unchanged blood through the respiratory center. Such experiments definitely indicate that the metabolism of the respiratory center itself and the volume-flow of blood through the center are important factors which must be considered in the ultimate explanation of the regulation of pulmonary ventilation. These conclusions are the result of a great number of diverse experiments devised to explain the harmful effects of hemorrhage and the beneficial effects of subsequent injection of non-nutrient solution.

In the submaxillary gland of the dog hemorrhage elicits a profound change in the volume-flow of blood. A 10 per cent. reduction of blood-volume may elicit a 65 per cent. reduction in the normal flow of blood. On reinjection of an equal amount of gum-saline solution the volume-flow may return to normal. The nutrient-flow (volume-flow × concentration of nutrients in the blood) necessarily increases.

Assuming that the function of a tissue is dependent on the nutrient-flow—hemorrhage and subsequent injection should affect the activity of the gland. Direct experiments show that a continuous secretion of saliva elicited by the intravenous injection of pilocarpin is diminished by hemorrhage and increased by subsequent injection of gum-saline solution.[2]

Observations led me to believe that the conditions in the submaxillary gland hold for the body as a whole and explain the general beneficial effects of injection of inert solution. Nevertheless, experiments were extended to other tissues as well and the same results were obtained.

In muscle, which comprises the bulk of the mammalian organism, hemorrhage and injection elicit like changes in volume-flow of blood. Similarly, the ability of the muscle to respond to repeated stimulation is diminished by hemorrhage and improved by subsequent injection of gum-saline solution.

The basal metabolism of the organism as a whole is likewise affected by hemorrhage and injection. Hemorrhage diminishes and subsequent injection of inert solution increases basal metabolism.

[1] From the Department of Physiology, University of Michigan, Ann Arbor, Michigan.

[2] Though on the whole during acute experiments gum-saline solution appears to improve the general nutrition and function of various tissues, the greatest care should be exercised in the use of this blood substitute in man. Extremely toxic effects with a large drop in blood pressure were not uncommon, even though a high grade of gum acacia and methods of purification were employed.

And, finally, hemorrhage and injection modify pulmonary ventilation—hemorrhage increasing and subsequent injection of gum-saline solution diminishing respiration. In certain instances, when the volume-flow is suddenly accelerated after hemorrhage by a rapid injection of gum-saline solution, respiration may stop for a minute or more. The initial effects are prompt and are produced by an acceleration of unchanged blood through the respiratory center.

The findings above establish a close relationship between tissue function and volume-flow of blood. It seems not improbable that the main effects of hemorrhage and injection are primarily due to changes in the transport of the respiratory gases, oxygen and carbon dioxide. And, if these conclusions regarding the effects of hemorrhage and injection on the gaseous metabolism of the submaxillary gland, striated muscle and the body as a whole are correct, I am inclined to carry them over to the respiratory center as well.

Assuming that hemorrhage leads to an impaired transport of carbon dioxide from the tissues it must also lead to an increased acidity of the tissues. There appears to be no reason for making an exception of the respiratory center. If injection improves the flow of carbon dioxide carriers and the transport of acid from the tissues, it should turn the respiratory center more alkaline in the same way that it turns other tissues more alkaline. I can see no cause for denying the respiratory center the right to live and to metabolize in conformance with the general laws of metabolism. It performs a continuous and most important function and presumably at the expenditure of considerable energy. I, therefore, prefer to look upon the respiratory center as an animate mechanism, having a definite energy exchange of its own, rather than as an inanimate object, operating on the principles of a motor. But admitting that the center possesses a metabolism of its own we must be prepared to accept the consequences. These, perhaps, are summarized in a theory of respiratory control which I have proposed. The theory in brief is this:

The respiratory center possesses an acid metabolism of its own.

The rate of formation of acid in the center and the rate of transport of acid from the center determine the acidity of the center.

The activity of the respiratory center is primarily regulated by the free hydrogen ions which are formed and accumulated within the center itself, as opposed to stimulation by the hydrogen ions brought to the center by the blood.

If living tissues form carbon dioxide in their metabolic processes it must necessarily follow that carbon dioxide flows from the tissues to the blood. This must hold for the respiratory center as well as for any other tissue. Only under special conditions, when the carbon dioxide tension of the arterial blood is increased above that in the respiratory center, can the flow be in the opposite direction. But the carbon dioxide tension of the blood, in so far as it determines the rate of diffusion of carbon dioxide from the center, regulates respiration.

My theory of respiratory control may now be elucidated by a further analysis of the prevailing theories. The theory of the specific stimulating effect of carbon dioxide has gained a number of adherents who have found that the stimulating action of carbon dioxide bears no relation to the hydrogen ion concentration of the arterial blood. For example, the administration of equal amounts of carbon dioxide before and after the administration of sodium bicarbonate elicits equal stimulation, though in the second instance the arterial blood is distinctly more alkaline than in the first. The action of carbon dioxide must, therefore, be specific.

If this be correct it is obvious that the theory of acid control is seriously weakened. But the fact that hyperpnoea is frequently associated with a very low carbon dioxide tension of the arterial blood throws considerable doubt on the importance of carbon dioxide as a specific stimulant.

Several important considerations have been overlooked. The hydrogen ion concentration of a buffer mixture is a function of the relative amounts of acid and base. For example, carbonic acid and sodium bicarbonate of the blood occur in the ratio of 1 to 20 with a pH of approximately 7.35. On the other hand, the acid effect of the blood on the interior of the living cell bears no relation to the acidity of the blood, but rather to the relative rates of penetration of the acid and base. An alkaline solution may exert an acid effect and an acid solution may exert an alkaline effect. Likewise, two solutions of equal acidity may exert different acid effects. Let us take two carbonate buffer mixtures in which carbonic acid and sodium bicarbonate occur in the amounts of 1 to 20 and 3 to 60. They have approximately the same hydrogen ion concentration, yet the second exerts a decidedly more acid effect than the first, due, as Jacobs suggested, to the greater penetration of carbonic acid.

The simplest demonstration of the acid effects of these solutions is to add phenol red and stratify. If they are brought to exactly the same hydrogen ion concentration, phenol red imparts the same color to both. But instantly following stratification there is a display of colors at the interface, indicating that the 1 to 20 solution is turning more acid and the 3 to 60 more alkaline. The effect is due to the relative

rates of migration of carbonic acid and sodium bicarbonate. Assuming that the 1 to 20 solution represents the respiratory center, and the 3 to 60 solution the arterial blood, it is evident that the acidity of the arterial blood is an unreliable index of the acidity of the respiratory center.

Take, for example, the effects of the administration of carbon dioxide and sodium bicarbonate. Carbon dioxide increases the hydrogen ion concentration of the blood, and sodium bicarbonate decreases it. Carbon dioxide invariably increases respiration, whereas sodium bicarbonate may have no effect whatever. The explanation of these dissimilar effects is demonstrated by a special method of recording the hydrogen ion concentration of the blood.

As the present methods for determining the hydrogen ion concentration of the blood are exceedingly unsatisfactory in giving a continuous picture of acid-base disturbances and are very slow in yielding data, I have felt the advantage of developing a continuous method of recording the hydrogen ion concentration of the arterial and venous blood. By means of a potentiometer, a specially devised electrode vessel, and manganese dioxide electrode placed directly in the blood stream, the hydrogen ion concentration is electrometrically recorded (Gesell and Hertzman).

With this method we compared the magnitude of change in acidity of the arterial and venous blood on the administration of carbon dioxide and found that the arterial blood turned considerably more acid than the venous bloods. Apparently the tissues absorbed carbon dioxide and acted as a buffer to the blood. If true, the acidity of the respiratory center must have been increased—accounting for the increased pulmonary ventilation. On the other hand, if we compare the magnitude of change in the hydrogen ion concentration of arterial and venous blood on the administration of sodium bicarbonate—we find the change virtually equal in both, indicating that sodium bicarbonate leaves the blood stream very slowly. If this be true, the injection of sodium bicarbonate has had little effect upon the alkalinity of the respiratory center, which, in turn, accounts for the lack of depression of respiration.

It seems difficult to align much evidence supporting the prevailing theory of regulation of respiration by the arterial hydrogen ion concentration. Perhaps the outstanding evidence is the remarkable constancy of the alveolar carbon dioxide tension and the arterial hydrogen ion concentration during rest, and the augmentation of respiration on the administration of carbon dioxide. But there are so many exceptions to the parallelism between pulmonary ventilation and acidity of the arterial blood that these observations lose their significance. Every form of anoxemia, hemorrhage, uncompensated heart lesion, anemia, etc., accompanied by hyperpnoea, may be associated with increased alkalinity of the arterial blood.

The continuous method of recording changes in the hydrogen ion concentration repeatedly reveals this lack of parallelism between arterial C_H and pulmonary ventilation. On changing from the administration of room air to nitrogen, respiration increases and the arterial blood turns alkaline. And changing back to room air the arterial blood turns acid, and respiration momentarily stops to continue again but at a diminished rate. Repeating the same experiment using pure oxygen in place of room air the results are even more striking. On the final administration of oxygen the increased acidity of the arterial blood is decidedly sharper and of greater magnitude, and correspondingly respiration is more suddenly stopped and apnoea more prolonged.

Hemorrhage offers another good example of the lack of parallelism between pulmonary ventilation and arterial C_H. It evokes increased pulmonary ventilation and is followed by decreased ventilation on reinjection. The increased ventilation is associated with increased alkalinity and the decreased ventilation with decreased alkalinity of the arterial blood. On the other hand, a comparison of the acidity of the venous blood and pulmonary ventilation shows a direct relationship. During hemorrhage the venous blood turns acid and ventilation increases. During injection the venous blood turns alkaline and respiration decreases. This correspondence undoubtedly shows the importance of volume-flow of blood. Though the arterial blood is considerably more alkaline than normal due to its greater ventilation in the lungs, yet when it passes through the tissues it becomes considerably more acid than normal. Hemorrhage undoubtedly increases the acidity of the tissues, indicating the possibility of acid stimulation of the respiratory center.

Further exceptions to lack of correspondence between arterial C_H and respiration are to be found in the experiments on mechanical asphyxia. Following artificial administration of room air the arterial hydrogen ion concentration increases very gradually during mechanical asphyxia, and hyperpnoea occurs with a relatively low arterial C_H. But in mechanical asphyxia following the administration of pure oxygen the hydrogen ion concentration increases to a considerably higher level before the faintest respirations are visible.

However, the theory of the regulative action of the arterial C_H is most generally accepted in the reviews which have recently appeared. As an example

we may cite from the report of the British Hemoglobin Committee:

A change in hydrogen ion concentration may be the primary cause of the alteration of the activity of the respiratory center. Under other circumstances the primary factor may be either shortage of oxygen or rise of temperature: both these conditions cause increased breathing and therefore will themselves tend to cause alkalemia. Here the change in the reaction of the blood is a secondary factor, but directly it is established its influence will obviously have seriously to be taken into account. The sensitiveness of the respiratory center to changes in hydrogen ion concentration is so great that an apparently trifling alteration of hydrogen ion concentration in the blood may result in great changes in breathing, and as the present methods of direct determination of the hydrogen ion concentration are often of insufficient delicacy to give us the accuracy of measurement that we require we are frequently forced to infer these changes by indirect methods involving measurements of the concentration of CO_2 in the alveolar air, of free and combined CO_2 in the arterial blood, and of the relative excretion of acids and bases in the urine.

And, to quote again in connection with increased respiration in diabetic coma:

However, it should be pointed out that even if no measurable increase of hydrogen ion concentration is found in diabetic coma, it is possible that the change may be so slight as not to be capable of measurements by the relatively coarse methods at our disposal and it may yet be sufficient to produce the characteristic respiration of diabetic coma.

I am inclined to believe that the evidence for direct regulative control by the arterial hydrogen ion concentration is lacking. The blood is too far removed from the tissues to exert that control. What then is the controlling mechanism? Oxygen undoubtedly plays an important rôle, but the exact mechanism is still debatable. Many observers suggest that lack of oxygen in the arterial blood has a specific stimulating effect on the respiratory center, independent of accompanying changes in acidity. Opposed to this view I have proposed a mechanism by which the supply of oxygen determines tissue acidity including the respiratory center.

Lack of oxygen means diminished oxidation and an accumulation of anaerobic metabolites. In isolated muscle, at least, lactic acid, which is a product of anaerobic metabolism, accumulates in greater amounts; and carbon dioxide, a product of aerobic metabolism, is formed in lesser amounts. The increase in lactic acid being proportionately greater than the decrease in carbonic acid, the rate of total acid production is necessarily greater during anoxemia than under more normal conditions. We have attempted to check these observations on the living animal. Although the complexity of the experiment offers considerable difficulties, the results on the whole indicate increased acid production during anoxemia.

Is the acid metabolism of the respiratory center similar to that of muscle? Dr. McGinty and I have attempted to answer this question. With a single stroke of a guillotine the normal unanesthetized dog was decapitated and the head divided into left and right halves. One half of the brain was instantly frozen in liquid air, and the other half chilled at later intervals varying in different experiments. Analyses of the two halves for lactic acid give both the normal lactic acid content and the rate of formation during lack of oxygen. Assuming the metabolic rate of the brain to be equal to that of the body as a whole, the analyses indicate that the acid production during lack of oxygen is sixteen times as rapid as during normal oxygen supply.

Accepting this assumption and the view that the hydrogen ion is a regulative factor controlling respiration, the probability of acid stimulation during anoxemia even in the presence of alkaline arterial blood must be seriously considered. But even granting a somewhat slower formation of acid during anoxemia the argument still holds. I refer to the disturbance of the coordination of the dual function of hemoglobin, another potent mechanism working towards increased acidity of the tissues. By virtue of the fact that oxidation of hemoglobin increases its acidity and reduction reverses this effect, the transport of oxygen and of carbon dioxide are closely interdependent. The reduction of oxyhemoglobin liberates a base which combines with the carbon dioxide and the HCO_3' ions coming from the tissues, a device maintaining a free diffusion of carbon dioxide and HCO_3' from the tissues to the blood. And, in turn, when the venous blood reaches the lungs oxidation of the hemoglobin increases its acidity and expels carbon dioxide into the alveolar air.

In anoxemia, whatever the type, less oxyhemoglobin is reduced as the blood flows through the tissues, but the production of acids continues. The coordination of the dual function of hemoglobin is broken and the mechanism for the transport of acid is markedly disturbed.

Though an acid mechanism for the respiration seems highly probable it hardly warrants the exclusion of a specific stimulating effect of lack of oxygen. Yet the fact that hyperpnoea from excess of oxygen as well as from lack of oxygen can be explained on the acid basis is rather significant. It is not at all unlikely that the hyperpnoea associated with oxygen

poisoning is a result of a disturbance in the dual function of hemoglobin. Under natural conditions the tissues receive their full supply of oxygen by the reduction of oxyhemoglobin, for the plasma holds very little oxygen in solution. But with excessive oxygen pressure the plasma holds enough oxygen in solution to provide the full quota. As a result —oxyhemoglobin is not reduced, no base is provided to carry the acid from the tissues which necessarily must turn more acid.

My theory of respiratory control may now be summarized.

Changes in the hydrogen ion concentration of the respiratory center rather than of the blood constitute the prime factor in respiratory control.

Since the supply of oxygen determines the absolute and relative amounts of lactic acid and carbon dioxide formed in living tissues, and since it controls the efficiency of transport and elimination of acid, it constitutes the normal and indirect regulator of pulmonary ventilation.

The effects of lactic and carbonic acid are additive. They are exerted indirectly by way of the blood from the tissues, and more directly through their formation in the respiratory center itself.

Diminished oxidation in the respiratory center leads to an accumulation there of the relatively poorly diffusible lactic acid in a relatively poorly buffered cytoplasm and lymph, no longer fully protected by the potential alkalinity of the blood, the dual function being disturbed by the diminution in the reduction of hemoglobin and the liberation of alkali as it passes through the center.

By virtue of its own metabolism and its extreme sensitivity to minute changes in its own hydrogen ion concentration the respiratory center is sensitive to minute changes in its own oxidations, and, therefore, to changes in the tension of oxygen in the arterial blood.

The capacity of the center to respond to changes in the arterial carbon dioxide tension consequent on fluctuations in the general metabolism, however, must also be a factor.[3]

ROBERT GESELL

UNIVERSITY OF MICHIGAN

SCIENTIFIC EVENTS

THE TOTAL ECLIPSE OF THE SUN OF JANUARY 14

THE January issue of *Popular Astronomy* gives an account of the various expeditions which have gone to Sumatra to observe the total eclipse of the sun of January 14. This eclipse promises to be well observed, although the path of totality lies across a part of the globe where there are no established observatories. The eclipse will begin at sunrise in East Africa and the moon's shadow will pass across the Indian Ocean, passing over a small island, Seychelles, about 700 miles east of the African coast, thence across the islands of Sumatra, Borneo and Mindanao, the southernmost one of the Philippine group, the eclipse ending at sunset in the Pacific Ocean.

Most of the observing stations will be grouped on the Island of Sumatra, where the observing conditions appear to be the most favorable, the duration of totality being upwards of three minutes. Unfortunately the maximum duration of 4 minutes 11 seconds occurs in mid-ocean. There will be three expeditions from the United States and one each from England, Australia, Germany, Holland, Italy and Java.

The American parties are: The U. S. Naval Observatory party, in charge of Captain F. B. Littell, including Professors George H. Peters and George M. Raynsford, astronomers in the Naval Observatory, and Dr. John A. Anderson, of the Mount Wilson Observatory. Their observing station will probably be at Tebing Tingge, Sumatra. The Sproul Observatory party, consisting of Director and Mrs. John A. Miller; Dr. Heber D. Curtis, director of the Allegheny Observatory, with Mrs. Curtis and Baldwin Curtis; Ross W. Marriott and Dean B. McLaughlin, of the Sproul Observatory; Adrian Rubel and Wilson M. Powell, seniors at Harvard, and Lamont Dominick, of New York. Their observing station will probably be at Benkoelen, on the west coast of Sumatra. The Harvard party, consisting of Dr. H. T. Stetson, director of the Harvard Astronomical Laboratory; Dr. W. W. Coblentz, physicist of the U. S. Bureau of Standards; Mr. Weld Arnold and Mr. W. A. Spurr, Harvard students. Their station will be at or near Benkoelen.

Dr. Horn d'Arturo, with an Italian expedition, will be stationed in Somaliland, near the east coast of Africa.

The English expedition sent to Sumatra by the "Joint Permanent Committee" will probably be at Benkoelen, a former British naval station. The party consists of Messrs. G. E. Barton, C. R. Davidson, F. J. M. Stratton, F. W. Aston and Colonel J. Whaley Cohen.

The Australian party under Mr. Z. Merfield, of the Melbourne Observatory, will probably be stationed at Benkoelen.

Professor Voûte from Lembang in Java will be near Palembang, north of the mountainous ridge that forms the backbone of Sumatra.

An expedition from the Royal Academy of Science of the Netherlands plans to occupy a station at Ta-

[3] Postgraduate lecture delivered before the Associated Anesthetists of U. S. and Canada, Atlantic City, May 26, 1925. (For references to original articles consult Gesell, *Physiological Review*, 1925, V, p. 551.)

langbetoetoe, about 10 miles northwest of Palembang. The party will consist of the following: Dr. J. van der Bilt, Utrecht Observatory; Dr. M. Minnaert, Helio-physical Laboratory, Utrecht; Dr. W. J. H. Moll, Department of Physics, University of Utrecht; Dr. A. Pannekoek, University of Amsterdam, and Miss J. C. Thoden van Velzen, graduate student of the University of Amsterdam.

It is reported also that the Einstein Foundation and the Potsdam Observatory are sending an expedition to Sumatra under the direction of Dr. E. F. Freundlich to secure observations for further study of the Einstein deflection of light rays in a gravitational field.

NATIONAL CONFERENCE ON OUTDOOR RECREATION

IN a letter written in April, 1924, President Coolidge appealed for nation-wide support of and participation in outdoor recreation as vital to the maintenance and development of American ideals. On the advice of a committee of cabinet members to whom the subject was referred, the President called a conference in May in which 128 national organizations participated. These were such as felt the use of the resources of the United States in land, water and wild life essential for the prosecution of their work.

The permanent organization effected at this first conference is based upon the President's committee, consisting of: *Chairman,* Hon. John W. Weeks, Secretary of War; Hon. Hubert Work, Secretary of the Interior; Hon. W. M. Jardine, Secretary of Agriculture; Hon. Herbert Hoover, Secretary of Commerce; Hon. James J. Davis, Secretary of Labor; *Executive Secretary,* Hon. Dwight F. Davis, Assistant Secretary of War.

With them is intimately associated the executive committee of the conference representing the various agencies and organizations cooperating in the movement. This committee consists of: Chauncey J. Hamlin, *chairman;* John C. Merriam, *vice-chairman;* Theodore Roosevelt, *honorary vice-chairman;* George Bird Grinnell, *honorary vice-chairman;* Vernon Kellogg, *secretary;* George E. Scott, *treasurer and chairman of Finance Committee;* Mrs. Herbert Hoover, Gustavus T. Kirby, Colin H. Livingstone, Barrington Moore, John Barton Payne, Charles Sheldon, Mrs. John Dickinson Sherwood, George Shiras, 3d, William A. Welch.

A group of departmental committees cooperates with the standing committees on education, human relations, playgrounds and athletic activities, land policies and wild life. The objective of the organization is the establishment of a national policy to unify and support the activities of the many federal, state, municipal and unofficial agencies striving to develop the recreational resources of the country. As a necessary feature of its work the conference proposes to promote the preservation and proper use of national resources. In the discharge of the functions of the conference the executive committee endeavors to elucidate broad policies and encourage special projects in line with these policies. It has been able to secure some financial support for administrative work and special grants for individual projects. It has published a few bulletins and has distributed other literature to express in authoritative fashion its purpose and policies. One of the most recent of these pamphlets covers the organization and program of work for 1924–1925. This is so remarkable a record, especially in view of the newness of the movement and of the limited funds at its disposal, that an outline of its contents is appropriate.

The program includes thirty projects of major importance in the field of conservation, each one of them intimately related to outdoor recreation. Under the direction of the general council, composed of one hundred men and women, leaders in the fields of recreation and conservation, each approved project is worked out by a special committee of those intimately related to the topic. Among the projects are: A survey of municipal and county park systems of the United States; recreational surveys of state lands and of federal lands; recreational value of highways; wild life legislation and administration; recreational needs of industrial workers; natural preserves; the establishment of national recreation areas; administration of the unreserved and unappropriated public lands; recreational values of waterways (aquatic pollution, and also drainage). Some of the projects have secured funds for their prosecution and are well advanced; others are still seeking financial support. But the record of actual achievement reflects credit on the sponsors of the movement.

A second conference has just been called for January 20 and 21 in Washington. The constituent organizations are invited to lay before this meeting studied conclusions on outdoor recreation and the conservation of wild life resources. The principal objects of the conference will be to consider federal and state responsibilities in outdoor recreation; to submit a national program for 1926 for the endorsement of the President's committee; and to make definite reports of the progress of surveys and other committee work. By virtue of its long and active interest in problems of conservation, the American Association for the Advancement of Science is deeply concerned in the work of the conference.

HENRY B. WARD

URBANA, ILL.

PLANS FOR THE DEVELOPMENT OF THE DEPARTMENT OF CHEMISTRY AT THE UNIVERSITY OF CHICAGO

A CITIZENS' COMMITTEE on chemistry to assist the University of Chicago in the development of its department of chemistry has been announced by Charles H. MacDowell, president of the Armour Fertilizer Works and chairman of the committee. The committee will undertake to raise, in cooperation with the university, $3,235,000 for a new laboratory building and the endowment of instruction and research in chemistry. The new laboratory building for research and graduate work, costing $1,285,000, is the immediate objective.

The committee is made up of twenty-six of Chicago's prominent business men. Harry Gottlieb, secretary of S. W. Straus and Company, is vice-chairman, and Dr. H. I. Schlesinger, professor of chemistry at the University of Chicago, is secretary.

In commenting upon the enterprise, Mr. MacDowell said:

> Chemistry is preeminently the science of industry. It deals with the composition and decomposition of matter. In the twenty-year-period since 1905 chemistry, particularly in its application to the industries, has made greater strides than in any other period of time in the history of the world. This, too, is the period of Chicago's great industrial growth. In these two decades much that was previously obscure and mysterious has been made clearer and more understandable—the ultimate composition of matter, the structure of the atom, the cause and effect of radio-activity, the structure of metals and alloys, the colloidal state, catalysis, heat and pressure chemistry, which is making epochal progress in Germany, organic chemistry, the rôle of endocrine secretions, hormones, vitamines in biological and physiological chemistry; all have affected directly and intensely the industrial life of Chicago.
>
> In the emphasis put upon graduate work and the development of highly trained investigators and professional experts, the University of Chicago represents in the Middle West, both in quality and purpose, what the graduate schools of the great eastern universities, such as Harvard, Yale, Columbia and Johns Hopkins, and the great universities of Europe, stand for. The department of chemistry at the University of Chicago has easily held its place among the leaders in this highest type of effort for many years, but it is now doubtful that it can do this longer if it continues to be impeded by enforced economies and the lack of financial support. The plans of the department for the next ten years, if adequate financial support is given it, are directed not only toward duplicating the recent advances of eastern institutions, but also toward research in chemistry surpassing in certain respects the present opportunities of the East.
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> A committee of the American Chemical Society, a few years ago, elaborated a plan for a ten-million-dollar Chemo-Medical Institute of Research, in which investigators in the fundamental sciences, chemistry and physics, would be working on the great problems of medicine jointly with medical research men. With the erection of the Albert Merritt Billings Hospital and other medical buildings at the university, and the installation of the new medical departments on a graduate and research basis, the university will have on its campus all the components necessary for such intensive cooperative work as presented by the proposed Chemo-Medical Institute, provided the department of chemistry is given the opportunity to carry out its plans to put itself on the same high plane as the medical departments will be. These plans involve the strengthening of the research staff by calling leaders in their fields to new professorships, and providing a new laboratory to be devoted exclusively to graduate and research work.

RESOLUTIONS ON THE DEATH OF DR. ALBION WALTER HEWLETT

THE medical faculty of Stanford University has passed the following resolutions in connection with the death of Dr. Albion Walter Hewlett, professor of internal medicine and executive head of the department of medicine:

> Dr. Albion Walter Hewlett, who died at the University of Pennsylvania Hospital, Philadelphia, on November 10, 1925, at the time of his death was professor of medicine and a member of the executive committee of the Stanford University School of Medicine;
>
> He aroused in his students an enthusiasm for the application of scientific methods to clinical medicine;
>
> He was a man on whose judgment the medical profession has learned to depend;
>
> His research in the field of pathological physiology and his lucid presentation of this subject have placed him in the foremost rank of medical scientists;
>
> To his associates, Dr. Hewlett gave unlimited interest in their problems, enthusiasm in their successes and an unwavering loyalty; be it, therefore,
>
> RESOLVED, That in the death of Dr. Hewlett the Stanford University School of Medicine has lost an inspiring teacher, the medical profession has lost a resourceful leader, medical research has lost a tireless worker and we, his associates, have lost a beloved friend.

SCIENTIFIC NOTES AND NEWS

THE Nichols medal in chemistry for 1925 has been awarded by the New York Section of the American Chemical Society to Dr. Samuel Colville Lind, associate director of the U. S. Fixed Nitrogen Research Laboratory, Washington, for his work on "The Chemical Activation of Alpha Particles."

THE Royal Academy of Belgium has awarded the prize for its 1925 competition on the subject "Une contribution importantee à la géométrie infinitésimale" to Professor W. C. Graustein, of the department of mathematics of Harvard University, for his memoir

entitled "Méthodes invariantes dans la géométrie infinitésimale des surfaces."

DR. SIMON FLEXNER, director of the Rockefeller Institute for Medical Research, was elected an honorary member of the Société de Pathologie Exotique of Paris at its session held on December 9, 1925.

DR. B. BROUWER, professor of neurology in the University of Amsterdam, has accepted an invitation to come to the Johns Hopkins University next April to deliver the annual lectures under the Herter lectureship fund.

DR. JOSEPH BLAYAC, professor of geology at the University of Montpellier, has been made a knight of the Legion d'Honneur.

SIR HUMPHRY ROLLESTON, president of the Royal College of Physicians, was awarded the honorary degree of doctor of laws by Birmingham University, December 8, on the occasion of the celebration of the centennial of the medical school.

DR. JAMES RICHIE has been elected president of the Royal Physical Society of Edinburgh.

DR. COUSOT, of Dinant, has been elected president of the Belgian Royal Academy of Medicine for 1926, with Professor Gallemaerts, of Brussels, and Professor Frédericq, of Liège, as vice-presidents.

DR. H. A. GLEASON, curator of the New York Botanical Garden, sailed for Porto Rico on January 14, where he is going to make a study of the plant life of the island. He will be assisted by Dr. Mel T. Cook, botanist at the insular experiment station at Rio Piedras, and later they will be joined by Dr. Nathaniel L. Britton, director-in-chief of the garden, and Mrs. Britton, honorary curator of mosses.

GEORGE H. H. TATE, of the American Museum of Natural History, and Harvey S. Ladew sailed on January 7 on an expedition for the museum through Bolivia, Peru and Argentina. They expect to spend six months in the little-explored mountainous region east of Cerro Real, collecting specimens of bird and animal life not now represented in the museum.

DR. SAMUEL J. RECORD, professor of forest products in Yale University, sailed on January 5 for Central America and Southern Mexico where he will make a study of trees and forest resources as a part of the tropical forestry program of the Yale School of Forestry.

PROFESSOR GORDON F. FERRIS, of the department of entomology at Stanford University, left last summer for Mazatlán, on the west coast of Mexico, to begin a year of travel in Mexico, Central and South America.

PROFESSOR ANDREW BOSS, chief of the division of agronomy and farm management of the Minnesota College of Agriculture, has gone to Washington as consulting specialist and will spend the next few months, on leave from the college, studying the work now being conducted in the division of farm management and costs of the Bureau of Agricultural Economics.

DR. V. V. NIKOLSKY, of the Moscow Tropical Institute, and Professor Kota Monzen, of the Imperial College of Agriculture and Forestry at Morioka, Japan, are visiting the United States.

DR. CHARLES V. CHAPIN, superintendent of health at Providence, R. I., and formerly professor of physiology at Brown University, will give the annual Sedgwick memorial lecture in Boston on February 12.

DR. STUART C. DODD, professor of psychology at Princeton University, will lecture before the Franklin Institute, Philadelphia, on January 14, on "Applications and Mechanical Calculations of Correlation Coefficients." On January 20, Dr. C. E. K. Mees, director of the research laboratories of the Eastman Kodak Co., will lecture before the institute on "The Color Sensitivity of Photographic Materials."

DR. W. B. CANNON, professor of physiology at the Harvard Medical School, gave a lecture on "Some Recent Observations on Sympathetico-Adrenal Mechanisms" before the Harvard Medical Society on January 12.

PROFESSOR MADISON BENTLEY, of the University of Illinois, delivered three lectures, during the first week of January, at Clark University in the Powell psychology lecture course, on the subject of "The Psychologies called Structural."

PROFESSOR LOUIS KAHLENBERG, of the department of chemistry of the University of Wisconsin, recently lectured before the section of the American Chemical Society at Purdue University on the subject: "The Separation of Crystalloids from one another by Dialysis, with Special Reference to Living Membranes." He also addressed the chemists at Indianapolis on January 8.

PROFESSOR A. E. DOUGLASS, of the University of Arizona, lectured at the University of Illinois on January 5 and 6 on "Big Trees and Climate of the Past" and "Recent Work on Mars."

J. A. FLEMING, of the department of terrestrial magnetism of the Carnegie Institution of Washington, retiring president of the Philosophical Society of Washington, gave an address before the society on "The Magnetic and Electric Survey of the Earth: Its

Physical and Cosmical Bearings and Development," on January 9.

ON December 16, Dr. George F. Kay, head of the department of geology of the State University of Iowa and state geologist of Iowa, delivered two lectures on "Pleistocene Geology" at the University of Toronto. On December 18, he spoke also to the members of the staff of instruction and graduate students of the department of geology at Columbia University, New York, on the subject "Recent Studies of the Pleistocene of Iowa."

PROFESSOR ALFRED O. GROSS, of Bowdoin College, gave an illustrated lecture before the Boston Society of Natural History on January 6 on "Glimpses of the Natural History of the Canal Zone, Panama."

DR. FREDERICK W. SEARS, of the New York State Department of Health, gave one of the De Lamar lectures at the School of Hygiene and Public Health, the Johns Hopkins University, on December 21 on "Some Problems in Rural Hygiene."

PROFESSOR WILLIAM B. SCOTT, professor of geology at Princeton University, read a paper on "The Isthmus of Panama as controlling the Animal Life of North and South America" before the American Philosophical Society of Philadelphia on January 8.

PROFESSOR MAX BORN, of the University of Göttingen, is giving a series of five lectures on Tuesday and Thursday afternoons in the Jefferson Physical Laboratory at Harvard University. The last lecture of the series will be given on January 19 on the subject of "Developments of the Quantum Theory."

THE Council of the University of Paris has appointed M. Delacroix, professor of psychology in the faculty of letters, to be the Zaharoff lecturer at Oxford University for the ensuing academic year.

W. G. A. ORMSBY GORE gave his presidential address before the annual meeting of the Geographical Association, London, on January 7. His subject was "The Economic Geography of the British Empire."

DR. HENRY CRAIN TINKHAM, dean and professor of clinical surgery and applied anatomy at the University of Vermont College of Medicine, died on December 6, 1925, aged sixty-nine years.

NATHANIEL T. BACON, chemist and technical expert for the Solvay Process Co., died on January 3 in his sixty-eighth year.

DR. GEORG KLINGENBERG, well-known German economist and engineer, head of the Charlottenburg Hochschule and director of the Allgemeine Elektricitäts-Gesellschaft of Berlin, died on December 7.

A JOINT meeting of the American Physical Society and the Optical Society of America will be held at McGill University, Montreal, on Friday and Saturday, February 26 and 27.

AT the Rochester meeting of the American Astronomical Society it was decided to meet with the American Association for the Advancement of Science at the end of the year. The meeting in September will be at the Maria Mitchell Observatory, Nantucket.

THE twenty-first annual meeting of the American Association of Museums will be held in New York City from May 17 to May 20. These dates have been fixed in proper relation to the meetings in Washington of the Association of Art Museum Directors, which will take place on May 10 and 11, and of the American Federation of Arts, May 12 to 14.

THE annual meeting of the American Engineering Council was held in Washington for three days beginning Wednesday, January 13. The executive committee and the administrative board convened on the opening day. The assembly of the council met January 14 and 15.

A COURSE of illustrated lectures has been prepared by the Massachusetts Institute of Technology under the auspices of the New England Association of Chemistry Teachers. The lectures will be held at the institute at 4.30 in the afternoon in accordance with the following schedule: January 6—"Atomic Structure," Professor W. C. Schumb; January 20—"X-Rays in Chemistry," Professor G. L. Clark; February 3—"Recent Developments in Radiation Chemistry," Dr. R. H. Gerke; February 17—"Valence," Professor Edward Mueller; March 3—"Colloid Chemistry," Professor D. A. MacInnes, continued on March 17; March 31—"Industrial Advances in Inorganic Chemistry," Professor J. W. Phelan; April 14—"New Uses of Carbon and Petroleum as Raw Material in the Chemical Industry," Professor J. F. Norris.

THE fourteenth annual meeting of the Oklahoma Academy of Science was held at the University of Oklahoma at Norman on November 27 and 28. This meeting was the first one held under the new plan inaugurated by the constitution adopted during the present year. About 150 were in attendance in the various sections. The address of the president, Homer L. Dodge, on "Research as a State Policy," was delivered at the annual dinner. Other addresses were made by Bradford E. Knapp, president of Oklahoma Agricultural and Mechanical College, and W. B. Bizzell, president of University of Oklahoma. There were ninety-five papers read before the scientific sessions of the four sections of the academy. Fifty-five new members were taken into the academy at the business

meeting and twelve were elected as fellows. Officers for 1926 are the following: President, J. H. Cloud, Stillwater; vice-president, Section A, L. B. Nice, Norman; vice-president, Section B, V. E. Monnett, Norman; vice-president, Section C, A. F. Reiter; vice-president, Section D, J. R. Campbell, Stillwater; secretary-treasurer, A. Richards, Norman; assistant secretary-treasurer, Herbert Patterson, Stillwater.

NEW light on the lost history and science of the ancient Mayas will be sought by an expedition which will leave New Orleans on January 9, led by Gregory Mason, explorer and writer, and Dr. Herbert J. Spinden, assistant curator of the Peabody Museum of Harvard University. At Belize, British Honduras, the party will leave the steamer to board a schooner for explorations along the east coast of the peninsula of Yucatan. At one anchorage after another the boat will be used as a base for investigations of the little known interior. Two other members of the party are Ludlow Griscom, assistant curator of birds at the American Museum of Natural History, and Ogden Trevor McClurg, of Chicago. Mr. McClurg, publisher and yachtsman, is familiar with Caribbean waters and has offered his services as navigator and hydrographer. The Mason-Spinden expedition will return to the United States in May.

A RUSSIAN expedition of exploration is to start shortly for the little known and remote desert island, Nicholas II Land, in the Arctic Ocean, recently rechristened Lenin Land. There are at least twenty-seven Russian scientific expeditions now exploring various parts of the Soviet's territory, working to add to our knowledge of geography, archeology, ethnology and other sciences.

DR. HUGO ECKNER has postponed his attempt to raise funds by popular subscription for building a super-Zeppelin for North Pole explorations, according to press dispatches. As a reason for the postponement Captain Eckner states that Germany's acute financial and economic situation does not warrant continuance of his efforts, which so far have raised only $300,000 out of $4,000,000 needed.

THE late Professor Edward S. Morse has bequeathed his library to the Imperial University of Tokio and his ethnological and zoological collections to the Peabody Museum, Salem. Bowdoin College will receive $1,000 and the Essex Institute, Salem, $5,000.

ANNOUNCEMENT has been made of the completion of an endowment fund of $100,000 to insure the continued publication of the *Bulletin* and the monthly *Transactions* of the American Mathematical Society and a quarterly journal published by the society.

GEORGE H. WALKER, of Boston, Massachusetts, one of the founders of the Walker Gordon Milk Company, has donated one thousand dollars to Iowa State College at Ames for the purpose of making a permanent investment, the annual returns from which are to be used as a prize for the student who shows the best knowledge and proficiency in the production of clean, pure milk.

A GIFT to Yale University from Charles Lathrop Pack, of Lakewood, N. J., of a demonstration forest for public education in forestry was announced by Yale University. The tract is located near Keene, N. H., and is adjacent to the forest land already owned by Yale, where experiments and research in the growth and production of white pine have been under way for several years. The new tract is directly on the trunk highway to the White Mountains. The prime purpose of the gift, according to Dean Graves, of the school of forestry in the university, is to carry on practical demonstrations of forestry which may serve as illustrations in educating people how forests may be scientifically handled. It will be a field museum with actual demonstrations of different methods of forestry that can readily be interpreted and understood by visitors.

ITHACA, N. Y., is going to turn 600 acres of unused land on the city watershed into a municipal forest. The planting of trees will begin next spring. Chairman William M. Driscoll, of the City Planning Commission, has placed an order for 10,000 white pine seedlings, 10,000 Scotch pine transplants and 1,000 black locust seedlings with the Conservation Commission for spring delivery as the first step in the planting of the forest.

A PHYSICO-CHEMICAL institute, to serve as central laboratories for Spanish scientific work, is assured by a gift of $200,000 from the Rockefeller Foundation. The site of the building will be provided by the Spanish government. It probably will be near the Museum of Natural Sciences in Madrid. Spain at present is lacking in experimental laboratories and the few which do exist have very little modern equipment.

THROUGH the kindness of Dr. F. B. Sumner, the University of California has presented the Museum of Zoology, University of Michigan, with the stocks of four of Dr. Sumner's mutant strains of the deer-mouse, the mutants called albino, pallid, yellow and hairless, and also with small stocks of four Californian subspecies of the deer-mouse. Further study of the heredity of these forms is to be carried on at the museum of zoology by Dr. L. R. Dice. Dr. Sumner is continuing at La Jolla his studies of the wild races of Californian deer-mice, and is also working on a fifth mutant form.

UNIVERSITY AND EDUCATIONAL NOTES

NEW YORK CITY COLLEGE has accepted a gift of $300,000, the largest single trust fund ever received by the university for educational purposes, from Henry and William J. Wollman, of New York.

AT the recent election in Louisville, the citizens voted about six to one to authorize the issue of $1,000,000 in bonds for the University of Louisville, and $5,000,000 for the public schools of that city.

PRINCETON UNIVERSITY will receive $20,100 by a bequest in the will of the late Charles Allen Munn, formerly editor and publisher of the *Scientific American.*

THE board of trustees of the University of Tennessee ratified on December 14 the expenditure of $280,000 for the construction of the first unit in the $1,000,000 program of expansion of the medical department of the university at Memphis.

DR. A. H. GIBSON, professor of engineering at the University of Manchester, has been elected dean of the faculty of science in the university.

DR. L. H. NEWMAN, formerly a fellow in medicine of the National Research Council under Professor Folin at the Harvard Medical School, has been appointed assistant professor of biochemistry at Howard University Medical School.

C. I. REED, former fellow in medicine of the National Research Council under Professor A. J. Carlson, University of Chicago, has been appointed as associate professor of physiology at Baylor University.

DR. JOSEPH K. BREITENBECHER, formerly professor of zoology at the University of Oklahoma, has been appointed to the teaching staff of McGill University.

DR. MAX MØLLER, of the University of Copenhagen, has arrived in Bangkok, Siam, to take the post of visiting professor of chemistry at the Chulalongkorn University under the auspices of the Rockefeller Foundation.

PROFESSOR LOTHAR SCHRUTKA, of the Brünn Technical School, has been appointed professor of mathematics at the Technical School at Vienna.

DISCUSSION AND CORRESPONDENCE

SIMPLIFIED LITERATURE CITATIONS

IN the issue of SCIENCE for November 6, 1925, Dean E. D. Merrill, of the University of California, makes "an appeal for simplified literature citations." His appeal is based on substantial grounds as judged by current practice and it should meet with a cordial response from writers, editors and publishers.

In referring to the method of citing literature used by the *Journal of Agricultural Research,* however, it would have been fairer to that publication had he chosen a more recent issue to exemplify his point. Beginning with the issue of No. 1, Volume 28, April 5, 1924, the journal adopted its present simplified form of citations. Examination of that form will show that the simplifying process has been carried even further than Dean Merrill recommends.

Is there sufficient justification for the time-consuming process of verifying the exact number of each type of illustration? Innumerable difficulties arise when checking the plates, figures, maps, charts, diagrams and portraits, particularly in foreign publications. Why not use the present *Journal of Agricultural Research* style and simply state, "Illus."? Or perhaps all reference to illustrations might well be omitted, as is now done in some publications.

Furthermore, so much difficulty was formerly encountered in bold-facing the volume number and having it appear correctly in type that the system was abandoned in favor of the much simpler method now used in the journal. Surely it is unnecessary to go to the trouble of bold-facing the volume number, if this form is used. No confusion is caused by this method and simplicity favors it.

M. C. MERRILL
OFFICE OF PUBLICATIONS,
U. S. DEPARTMENT OF AGRICULTURE

ODDLY enough, on the same day that the writer read the letter, "An appeal for simplified literature citations" by E. D. Merrill in SCIENCE for November 6, he had already encountered similar difficulties, and had even thought of writing something on the subject.

Such difficulties, small in themselves, but typical of many experiences, will serve to emphasize the need of a uniform, and in some cases, more convenient form of citing references.

It is a regulation of this institute that references shall be presented in the same form as used in *Chemical Abstracts.* In consulting an English publication, and quoting a paper that included a bibliography, the question at once arose as to whether the references were in the proper form. The translation of one style to another should certainly not be necessary, nor should the question ever arise to change one's train of thought, for the loss is not merely the few seconds or minutes required in comparing each refer-

ence, but the time wasted in picking up the thread and resuming work.

By way of suggestion, the form used in print should be reproducible in handwriting or on the typewriter without confusion. The system of citations employed by *Chemical Abstracts* is probably the most carefully worked out of any in use, and is rapidly becoming recognized as a model. It employs bold-faced figures for volume numbers, which are preferable to either Roman numerals or ordinary figures. For example:

J. Am. Chem. Soc. **47**, 1445–7 (1925).

In manuscripts for printing, bold-faced type is indicated by underlining with a wavy line. Since the typewriter has no such character, editors understand what is meant if volume numbers are underlined. If there is danger of confusing the volume and page numbers the same thing can be done in handwriting. Setting off the year in parentheses avoids any danger of confusing it with page numbers.

It is to be hoped that enough interest will be manifested in this present rather aggravating situation to result in a uniform international system.

CHAS. F. GOLDTHWAIT
MELLON INSTITUTE OF INDUSTRIAL RESEARCH,
UNIVERSITY OF PITTSBURGH

DEAN E. D. MERRILL'S recent appeal in SCIENCE for "simplified literature citations" merits consideration, and there will doubtless be general approval of the purpose he has in mind. However, there is something to be said, at least for abstract journals and other publications dealing mainly with current literature, in using in citations the periodical number in addition to the other data. Its inclusion takes some space and adds to the complexity of the title, but librarians and others seem to regard it as very valuable and helpful. It is a particular convenience in handling references in current or unbound periodicals, and while not indispensable, the thirty-five years' experience with *Experiment Station Record* indicates that it is well worth the space it occupies. Facility and accuracy in the handling of references are surely relevant considerations in making citations, and their promotion may be as desirable as an extreme of brevity.

HOWARD LAWTON KNIGHT
Experiment Station Record,
U. S. DEPARTMENT OF AGRICULTURE

IS THE AUTOMOBILE EXTERMINATING THE WOODPECKER?

So frequently had I seen the dead bodies of the red-headed woodpecker along the highways that recently when starting out on a drive of some 220 miles I decided to make a careful count of all the birds of this species both dead and alive that were to be seen along the road. Leaving Iowa City the second day of August I drove through a section of Iowa where the red-headed woodpeckers are probably more numerous than in any other part of their range. During the first part of this trip no dead woodpeckers were seen, while over 100 live birds were recorded. On the last 120 miles of the trip, however, twenty-one dead woodpeckers were observed as well as eighty-two that were alive.

Excepting in cases where the woodpeckers were too badly mangled, an examination of the crops and stomachs was made. As a result of this examination I found that without exception they contained such food as bread crumbs, sweet corn, bits of doughnuts and pieces of apple. The stomach contents would seem to indicate that these birds are in part attracted to the street by waste from the lunch baskets of passing tourists and by chance garbage that has been carelessly thrown into the street. This would suggest to those who would save the woodpecker the desirability of not throwing any lunch or other food along the right-of-way.

The red-head is a fearless bird. He will remain in the path of an approaching car until it is close upon him. Then the clumsiness of his feet that were intended for clinging to the side of a tree prevent him from making the quick get-a-way that saves the lives of many of the other species of birds that feed in similar manner. Moreover, the telephone and telegraph poles along the way, affording as they do excellent perching and nesting places, no doubt attract the woodpeckers to the highway.

I believe that the reason that no dead woodpeckers were found on the first one hundred miles of the trip, although one hundred live birds were seen, is due to the fact that much of this part of the road was a detour and so not extensively used by tourists. This would eliminate the waste from lunches, and so offer no inducement to the birds to go into the street.

Four weeks later on my return trip over the same road I found comparatively few woodpeckers, noting only twelve live birds and five dead ones. The scarcity of woodpeckers at this time may be accounted for by the fact that these birds, changing their diets as they do with the seasons, are much more likely to be found in the hardwood groves than in the open during the month of September.

One can not tell with any surety whether the dead birds seen on the highway were killed on one day or on three days. Neither can one say that because

he found twenty dead birds in traveling over a certain one hundred miles that he would find ten times that number if he traveled one thousand miles. The red-headed woodpecker is considered a common bird throughout its range, but its preference for certain localities within this range makes it exceedingly numerous in some places, while there may be miles and miles of country round about where it is scarcely ever seen.

Generally speaking, the red-headed woodpecker seems to be the only species of wild life that is killed in any great numbers by the automobile. Despite the mishaps to individuals, the species as a whole seems to be holding its own and is to-day, without doubt, one of the most numerous of our native birds.

In addition to the twenty-one dead woodpeckers I also noted the numbers of all other killed animals along the road, the following list being the result of my observation:

Chickens	30
Rabbits	3
Skunks	2
Striped spermophile	2
Cat bird	1
Sparrow hawk	1
Cow bird	1
Garter snake	1
Total	41

In addition to the preceding list I might add the dead insects that were taken from the back of my car radiator and the catch pan below, although they were accumulated in a much longer run than the 220 miles to which I have here referred. Fully one pint was removed, in which motley collection I was able to recognize twenty grasshoppers, seventeen cabbage butterflies, sixteen botflies, fourteen honey-bees and parts of many house flies, moths and beetles. These insects were the residue accumulation of about two thousand miles of travel; many more, of course, had disintegrated or fallen out along the way. One pint is, I believe, a fair estimate of the quantity of insects killed by a car of average size in traveling two thousand miles. Larger cars, traveling at a higher rate of speed, would kill many more, while smaller cars would run correspondingly under this amount.

Incidentally it may be of interest to estimate the size of a pile of insects that would be killed by all the cars of this country in driving two thousand miles. Allowing one pint to be a fair average for one car, the eighteen million cars now in use would make a killing which would be thirty feet square and as high as the Woolworth building.

Investigating the contents of my car radiator was suggested to me by the Rev. W. E. Waldeland, who found a similar collection in his own automobile. I am further indebted to him for the following notes which he kindly made for my use.

We have just returned from a 2,000 mile auto trip through Iowa, Wisconsin and Minnesota. On this trip we saw less than a dozen red-headed woodpeckers killed by cars, and we saw but few other killed wild animals. The total of all species will not exceed fifty. Wild life seems to be more fortunate in this matter than the farmer's chickens.

My own observation has been that the latter are killed in larger numbers than the wild creatures, but that is a matter which is up to the farmer. He seems to think it less expensive to have a few fowls killed by cars than to fence them in. And then, too, he is able to eat the killed chickens if he sees them in time.

HOMER R. DILL

UNIVERSITY OF IOWA

DATE OF CHANNEL TRENCHING IN THE SOUTHWEST

THE article by Kirk Bryan on the "Date of Channel Trenching (Arroyo Cutting) in the Arid Southwest," in a recent issue of SCIENCE[1] was of considerable interest to me. The conditions mentioned as occurring in Gila Valley were of special interest since I came to that valley in February, 1900, and remained a resident for 23 years. As a large part of that period was spent in the Forest Service, I became an observer and student of erosion, grazing and the effect of the elements on the earth's surface.

The first herd of cattle was driven into the watershed of Gila River by Z. C. Prina in 1884, and located on Bonito Creek some 18 or 20 miles north of Solomonsville. Mr. Prina became a prominent citizen of Arizona, well known as a reliable and level-headed man of honor. I can testify to these qualities of my own knowledge. Mr. Prina described the country as consisting of fields of waving grass in 1884. The Gila River was a very small stream confined in a narrow shallow channel the banks of which were lined with willows, brush and sod grasses. The news of the presence of abundant feed and no cattle spread rapidly eastward and in the next two years thousands of head of cattle were brought in. Gila River remained within its banks until 1896, when, according to Mr. Prina, a flood topped the banks, 12 years after the introduction of cattle. Floods, thereafter, were an annual occurrence but as late as 1900, when I arrived in the valley, it required no effort to toss a stone across the river channel from bank to bank. During the drought,

[1] SCIENCE, vol. LXII, pp. 338–344, October 16, 1925.

which started in 1899 and extended to the late summer of 1904, large numbers of cattle were forced to browse on shrubs of all kinds and large herds came to the river to drink. As a result, the willows, shrubs, etc., along the banks of streams, were practically killed off. Large numbers of cattle died from starvation, and when the drought broke the unprotected banks of the streams melted away like sugar, until the channel reached the mammoth proportions of to-day.

As to the San Simon, I do not recall being told about the small channel being dug by the settlers; however, in 1900 San Simon Wash, within the present irrigated district, was not over 12 or 15 feet wide by 2 or 3 feet deep. Out on the "Mesa," just outside the irrigated district, there were two or three well-defined cattle trails made in going to and from water in the Gila, but the area was so smooth that one could cross anywhere with a team and buckboard. These cattle trails were soon formed into small arroyos and are to-day as described by Mr. Bryan.

It has been my observation, from what would be learned from the "old timer," that arroyo cutting started, in most cases at least, by overgrazing, since in almost every instance they claim that these arroyos did not exist at the time of the introduction of cattle.

T. T. SWIFT

TONTO NATIONAL FOREST,
PHOENIX, ARIZONA

EVOLUTION AND THE UNIVERSITY OF NEBRASKA

THE New York *Times* of November 29, 1925, quotes Professor Henry Fairfield Osborn as saying in an address before the science section of the Association of Colleges and Secondary Schools of the Middle States that "in a recent journey through Nebraska he learned that even in the state university there was a 'hush' at the word (evolution)" and that "no teacher in the whole state of Nebraska is entirely free to be sincere, but is more or less obliged to dissemble his real beliefs." We do not know the source of Professor Osborn's information but wish to state emphatically that his information is absolutely erroneous and unrepresentative and therefore misleading and unjust. In the state university, from the chancellor down to instructors, there has never been a "hush" on the freest discussion and most open teaching of evolution.

In a recent address before a large religious body Chancellor Avery said, "I am an evolutionist" and "there is no inconsistency whatever between Christianity and evolution, and when linked together they can do marvelous work for the kingdom of God." In an interview in the Omaha *World Herald* of May 22, 1925, the chancellor stated that "at the state university evolution is taught as a theory, not as a dogma."

The departments of botany, geology, sociology and zoology teach evolution with the utmost freedom.

Professor E. H. Barbour, head of the department of geology and a close friend of Professor Osborn, says that "in the geology department our only solicitude is for truth. We take facts as we find them. We hold that the truth is sacred above all things." Professor Barbour gives a lecture on evolution each semester before some two thousand freshman students.

The department of zoology teaches evolution in every course and offers a special course each semester to a large group of students under the specific title of "Evolution."

We recently addressed a large group of science teachers of the state on the subject "Evolution an Inspiration." All members of the university faculty from the chancellor down hope that evolution may be kept out of controversy and left in the realm of scientific truth.

FRANKLIN D. BARKER

UNIVERSITY OF NEBRASKA

SCIENTIFIC BOOKS

SOME RECENT BOTANICAL PUBLICATIONS

THE multiplication of general text-books on botany seems likely to continue until each university is represented by such a text. This arises from the fact that conditions of instruction vary so widely that instructors are compelled to adjust their presentation of botany to the local situation. When this is successful, it is likely to result in another text-book. Attention may be called to two recent illustrations of this fact.

At the University of Wisconsin, six botanists have cooperated in the preparation of a general text.[1] The authors are not differentiated in the text, thus segregating the various fields of botany, but have treated botany as a unit. For example, structure and function are so intimately associated that morphology and physiology are not segregated. In making such a composite presentation, the cell is first considered as the unit of structure and function, and this is followed by describing its combinations and activities in the various organs, leading up to a synthetic view of the plant as a whole. Following this presentation of the plant as a working organism, the great groups are considered, from algae to seed plants. The volume closes with a presentation of evolution and heredity and finally a consideration of the economic

[1] Smith, G. M., Overton, J. B., Gilbert, E. M., Denniston, R. H., Bryan, G. S., and Allen, C. E., "A Textbook of General Botany," The Macmillan Co., New York. 1924.

significance of plants. The volume is certainly very suggestive to teachers, and should help in somewhat reorganizing the presentation of botany as a unified subject, with such changes as local conditions may demand.

Holman and Robbins[2] have also published a general text, which is the result of experience with courses given to agricultural students and liberal arts students. The material of these two courses is combined in the text, and the method of presentation adjusted to these particular groups of students. It is interesting to note that the order of presentation is similar to that of the preceding text. Beginning with the cell, there follow chapters on the structure and activities of the whole plant and its organs, up to seed germination. This is followed by a description of the four great groups, and finally a chapter on evolution and heredity. In short, this text first develops knowledge of the plant as an individual organism, and then pictures the plant kingdom as a whole.

Another general text may be referred to, which has a more special purpose than the preceding ones, Tansley,[3] of England, has prepared a text intended primarily for medical students and those who do not intend to continue work in botany. This somewhat restricted audience naturally influences the selection of material for presentation. As in the preceding texts, however, plants are presented under two aspects, namely, the chemical and physical nature and behavior of organic substances, followed by a survey of the plant kingdom from algae to seed plants, type plants being selected to illustrate biological principles. The author presents his material in such a way that the result should be a general appreciation of life processes, rather than merely details of structure and classification.

One of the much needed special texts has just been prepared by Eames and MacDaniels,[4] of Cornell University. It is an introduction to a great and growing field which has never been presented in an organized way. Although introductory, it furnishes a working basis in this field, and incidentally clears up a much confused terminology. The book does not include the great mass of facts recorded in this field, but uses well-chosen illustrations. The emphasis is put on laboratory practice, for which the book furnishes a background. The sequence of subjects is said to be the result of experience with students. Only vascular plants are considered, with an occasional mention of lower forms. The term anatomy includes histology, which deals with internal structure, but excludes cytology as a special field. Beginning with the cell, the various tissues and organs are described, and the book closes with a sketch of the history of the subject.

In addition to these general texts, there have appeared recently a number of books dealing with special groups. Among these a notable one is by Skene,[5] of Aberdeen, who bases his presentation of the flowering plants upon experimental physiology. The book is full of information concerning modern research on plant life and behavior. It is written in a style that holds the interest of the students and gives a well-rounded view of the seed plant as a living organism. Some idea of the presentation may be obtained from the headings of the six chapters, namely, soil relationships, assimilating of carbon and transpiration, special forms of nutrition (as parasites, etc.), mechanical problems and protection, reproduction and dispersal and development.

A notable book dealing with a special group has been issued from Kew Gardens, by Dallimore and Jackson.[6] It is an elaborately illustrated work on the Conifers (including Ginkgoaceae), as announced "from the point of view of the gardener, forester and student rather than the botanist." In other words, it is not technical, but presents all the known species in simple language. An expedition to China yielded many new forms and facts of distribution. The descriptions were obtained from living plants, as well as herbarium specimens, the great Conifer plantation at Kew and many estates furnishing living material.

Buller[7] is continuing his important work on fungi, the second volume dealing with the problem of spore discharge in the Hymenomycetes. The details of structure and behavior are presented clearly in text and illustration. He finds great variation in these features, and recognizes several distinct types.

One of the most important special publications recently issued is that by Britton and Rose,[8] who have completed their presentation of the Cactaceae after

[2] Holman, R. M., and Robbins, W. W., "A Text-book of General Botany for Colleges and Universities," John Wiley and Sons, New York. 1924.

[3] Tansley, A. G., "Elements of Plant Biology," George Allen and Unwin, London; Dodd, Mead and Co., New York. 1922.

[4] Eames, A. J., and MacDaniels, L. H., "An Introduction to Plant Anatomy," McGraw-Hill Book Co., New York. 1925.

[5] Skene, Macgregor, "The Biology of the Flowering Plants," Macmillan Co., New York. 1924.

[6] Dallimore, W., and Jackson, A. Bruce, "Handbook of Conifera," Longmans, Green and Co., New York. 1923. Printed in London.

[7] Buller, A. H. R., "Research on Fungi," Vol. II, Longmans, Green and Co., London. 1922.

[8] Britton, N. L., and Rose, J. N., "The Cactaceae," 4 vols., Carnegie Institution. 1919–1923.

twenty years of study. It is a fine example of co-operative work in discovering the relationships of an unusually difficult group. Not only was field material studied, but the plants were cultivated in greenhouses. The work also involved visits to Europe to examine type material, and also extensive field trips into the various cactus regions. The work was financed not only by the Carnegie Institution, but was aided also by the New York Botanical Club, the U. S. National Museum and the U. S. Department of Agriculture. As a result, 1,255 species are presented, under 124 genera.

There is also an increasing number of publications dealing with special subjects, especially cytology. Attention may be called to the work of Stomps[9] on heredity and cytology, which summarizes the most important recent results. It presents the subject under three general divisions, namely, the cell, with its ordinary division and reduction division; heredity, calling attention to the functions of the nucleus; and the relation of chromosomes to heredity. In connection with this last topic an account is given of the important researches, and the opinion is given that Morgan's work with Drosophila will hold.

Another cytological work by Schürhoff[10] is a monograph on plastids, dealing with the details of their morphology, cytology, composition, physiology and pathology. It is a general summary of our knowledge of plastid organization and behavior and brings together a mass of scattered information.

In this connection, attention should be called to the fourth edition of Chamberlain's[11] "Methods in Plant Histology." This edition is an excellent illustration of the rapid advances in cytological technique. The first edition was published in 1901, the second in 1905, the third in 1915, and now it was found necessary to almost completely rewrite the fourth edition. Since this book is a standard in its field, this edition will serve the purpose of bringing much technique up to date.

An interesting and unique book, which occupies a field of its own, is by Trelease.[12] It is a companion to his "Plant Materials of Decorative Gardening," published in 1917. It is a pocket manual for field use, and presents keys for the recognition of woody plants in winter, when the flowers and leaves used by the ordinary manuals are lacking. It enables one to recognize a plant from its winter twigs, using such characters as leaf scars and bud and pith characters. Since the characters used are "small differences in small parts," a pocket lens is necessary, supplemented by text illustrations. The Conifers are excluded, because they are evergreens, retaining the characters used in classification. The amount of work involved in this assembling of a new group of characters may be inferred from the fact that 328 genera are described in 94 families. There was no attempt to differentiate all the species and varieties, but this little book will certainly make an excellent companion in winter botanizing.

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[9] Stomps, Theo J., "Erblichkeit und Chromosomen," Jena. 1923.

[10] Schürhoff, Paul N., "Die Plastiden," Berlin. 1924.

[11] Chamberlain, C. J., "Methods in Plant Histology," University of Chicago Press. 1924.

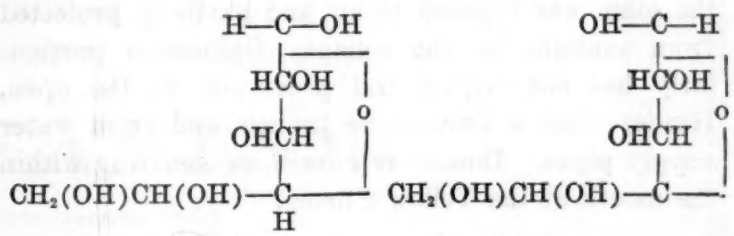
[12] Trelease, Wm., "Winter Botany," Publ. by author, Urbana, Ill. 1925.

SPECIAL ARTICLES

ON THE α- AND β-FORMS OF SUGARS AND OF SUGAR DERIVATIVES

THE differentiation between the α- and β-forms of sugars is accomplished according to a rule introduced by Hudson. According to this rule, in a pair of sugars either substituted or non-substituted, the one with a higher dextrorotation (or lower levorotation) is recognized as the α-form and that with a lower dextrorotation (or higher levorotation) is regarded as the β-form. The rule of Hudson led to many important conclusions regarding the configurational relationship of carbon atom (1) of simple and complex sugars. The rule, however, was based on an entirely arbitrary principle. In the course of recent work, there arose doubts as to the applicability of Hudson's rule to every sugar derivative. This circumstance led to a new method for differentiation between the α- and β-forms which is based on a rational and not an arbitrary principle.

If solid models of the α- and β-forms are constructed, it becomes evident that the mutual relationship of the free hydroxyl on carbon atom (1) and of the extra nuclear carbon atom or atoms are different for the two forms. Thus, for the common glucose, the arrangement will be the following:



α–form. β–*form.*

It is seen that in this instance the old α-form may be regarded as a trans-form with respect to the rigid ring and the old β-form as the "cis" form. In the <1, 4> oxidic galactose the α-form is the cis-form

and the β- the trans-form. The arrangement will be analogous to malic (cis) and fumaric (trans) acids. In the latter group of acids the trans-forms are distinguished from the cis-forms by their melting points and other physical properties. Also in the sugar series the trans-forms should possess a higher melting point, and this property may serve for differentiation between the two forms of sugars. If it is agreed to name as α-forms all those in which for the d-series the hydroxyl of carbon atom (1) is to the right, then for the <1, 4> oxidic glucose the α-form is the trans-form and for the <1, 4> oxidic galactose, it is the cis-form. A survey of sugar derivatives in the light of the new principle is in progress.

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IRON BACTERIA

AT the Iron Spring near Mirror Lake in the Yosemite National Park the writer collected some ocherous scum. On microscopic examination the material was found to contain the iron bacteria: *Leptothrix ochracea* Kützing, *Spirophyllum ferrugineum* Ellis and *Gallionella ferruginea* Ehrenburg. *Crenothrix polyspora* Cohn may have been present, but its identification was not certain. The discovery is of interest because of the presence of Gallionella and because of the mode of occurrence. Gallionella is reported by Harder[1] as known to him in only three localities in the Unitde States; and has since been reported by Inman[2] as occurring in the chalybeate spring at Yellow Springs, Ohio.

The Iron Spring water in the Yosemite, which apparently filters through the granitic talus and morainal material prevalent in that part of the valley, issues as a seep through rich, black, sandy soil. The amount of iron available in the water has not been determined but is probably insignificant. A clear spring for drinking has been made by sinking a tile in the soil.

The collections of the bacteria were made from the small pools and seeps directly on the black soil where the scum was exposed to air and partially protected from sunlight by the foliage. Gallionella particularly has not been found previously in the open. Harder cites it from mine tunnels and from water supply pipes. Inman[3] reports it as occurring within the mouth of the Yellow Spring.

[1] Harder, E. C., "Iron-depositing Bacteria and their Geologic Relations," U. S. Geol. Survey Professional Paper 113, 1919.

[2] Inman, O. L., "Iron-depositing Bacteria." SCIENCE, n.s. 58, p. 13, 1923.

[3] Personal communication.

The water from the Iron Spring is encrusting pebbles and twigs, and below the spring for some distance the rust-colored coating can be noticed. The encrusting material, examined under the microscope, shows granules of the iron hydroxide, and also what appears to be the deformed tube-like Leptothrix. Nothing suggesting the other bacteria was found in the coating.

O. L. Inman reports as follows on the iron bacteria from the Yosemite:

> The collected material contains Leptothrix, Spirophyllum, and Gallionella, the first in greatest abundance. The staining of the iron bacteria has been noted as a difficult matter (c.f. Harder). As a rule they stain with great slowness, if at all. The Yosemite iron bacteria stained very rapidly both with methylene blue and carbol fuchsin. No definite reason can be assigned, though several suggestions may be made to explain the difference in staining properties. It may be due to differences in the organism, but variations in the thickness and penetrability of the sheaths must be considered. It should be remembered that it is the organism and not the sheath which absorbs the stains. Organisms having thick sheaths—possibly because there is more iron in their environment—may therefore not absorb the stains readily. In some instances it is not possible to tell whether the organisms are alive or dead; staining properties will, of course, differ. The specimens from the Yosemite absorbed the stains more rapidly than any I have seen, *i.e.*, in a few seconds.

The writer also found iron bacteria, chiefly Gallionella and Spirophyllum, in the scum on springs at and just above high tide level at the foot of the low sea-cliffs at Moss Beach, California, some twenty miles south of San Francisco along the sea coast. The springs represent the seepage from the poorly consolidated, coarse, Pleistocene sands. Unlike the Yosemite occurrence of the bacteria there is plentiful iron present, since the sand grains are coated and loosely cemented with the iron oxides.

A question which the last occurrence of the bacteria raises is in regard to the possible influence of iron bacteria in the original deposition of the iron oxide cement of the sands. Bacteria, iron bacteria among many other forms, may be important factors in the cementation of sand and gravel materials. Such would be a logical conclusion to draw from the results of recent studies in bacterial deposition: not only does the activity of the low forms of life provide material for the mass of rocks themselves, but also the material for binding clastic sediments. However, very little direct evidence is at present available regarding this sort of cementation.

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